Bias in Annual Harvest Rates Estimated for White Sturgeon of the San Francisco Estuary

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Introduction

Annual harvest rate for White Sturgeon is one of many metrics produced by the Department of Fish and Wildlife sturgeon population study (the study) and rates have been reported or alluded to at intervals since 1959 (Chadwick 1959, DuBois and others 2011, DuBois and Gingras 2012, Kohlhorst 1979, Kohlhorst 1980, Kohlhorst et al. 1991, Kohlhorst and Cech 2001, Miller 1972, Schaffter and Kohlhorst 1999, Skinner 1962). The rates have been used to monitor the impact of fishing regulations, estimate natural survival rates, and recently to estimate abundance (Gingras and DuBois 2012). Calculated from tagging data and information provided voluntarily (e.g., by mail) by anglers on their capture of tagged fish, the rates can be biased and — because White Sturgeon (like most sturgeon) is sensitive to harvest — it is important to understand the likely direction and magnitude of any bias.

The annual harvest rates reported to date have not accounted for possible biases due to mixing of tagged fish with un-tagged fish, tag shedding, delayed mortality attributable to tagging, or angler willingness to contact the Department. Of those issues, only the level of mixing might cause estimated rates to be biased high and we plan to look into the potential for bias in rate attributable to the level of mixing. Tag shedding was assessed with a double-tagging study by Miller (1972) who characterized shedding as 'negligible'. Delayed mortality attributable to tagging has not been assessed, but survival of tagged fish is a top priority of the study and we suspect mortality is quite low. Angler willingness to contact the Department stands out as a potentially-substantial bias.

Angler willingness to contact the Department was first addressed in 1967 by placing a prominently-labeled $5 reward tag on each fish (Miller 1972) and was addressed in the 1980s and 1990s by increasing the reward value to $20. Starting in 1998, angler willingness was further addressed — and the groundwork for an assessment was laid — by placing a $20, $50, or $100 reward tag on each fish. In an effort (in part) to better assess angler willingness, 2010-present Sturgeon Fishing Report Cards (Report Cards) require(d) anglers to record the harvest and/or release of fish tagged by the study. Here we use reward value and Report Card data to briefly investigate angler willingness during the period 1998-2012.

Investigation

Because the study releases approximately the same number of tags with each of the 3 reward values, anglers returning Report Cards have reported the annual capture of many White Sturgeon (3000-5000), and documenting capture of tagged fish is required for Report Card holders, we hypothesized that anglers returning Report Cards would report having caught approximately equal proportions of fish bearing each of the 3 rewards. The number of tags reported by Report Card (years 2010-2012) is 13@$20, 6@$50, and 10@$100, which is not equal proportions but is substantially different than the

proportion of tags — 16@$20, 16@$50, and 37@$100 — reported voluntarily during the same period. Anglers voluntarily reported (years 1998-2012) 162@$20, 244@$50, and 338@$100 tags. These results strongly suggest that reward value affects the willingness of many anglers to voluntarily contact the Department about recapture of tagged fish and that annual harvest rates calculated without consideration of reward value are biased low.

To get a sense of the magnitude of bias attributable to angler willingness, we calculated annual harvest rates from the following permutations of data: (1) The study's long-time 'conventional' algorithm that considers neither the reported fate of recaptured fish or reward value, (2) recaptured fish reported (voluntarily or by Report Card) as kept but without regard to reward value, and (3) recaptured fish reported (voluntarily or by Report Card) as kept by reward value. We found that rates calculated using $100 tags only were almost always substantially higher than rates calculated from other permutations and there is something of an increasing trend in rate over time (Figure 1). We suspect the time-trend is attributable to a combination of the economic downturn, additional outreach by the Department, and 2007-present reduction in the maximum size of White Sturgeon that may be harvested legally. These results strongly suggest that rates calculated from $100 tags are closest to accurate but are likely still biased somewhat low.

Discussion

Having seen from the present investigation that estimated annual harvest rates calculated without consideration of reward value tended to be biased substantially low from 1998-2012 due to angler willingness, we suspect that rates calculated prior to that period — when no information on angler willingness was available — were also biased low such that harvest contributed more than previously thought to observed declines in the fishery and fish population. Estimated rates on fish ≥ 102 centimeters Total Length (TL) in the late 1960's were approximately 7% (Miller 1972) and catch-per-unit-effort declined substantially during the period 1964-1974 (Kohlhorst 1980), and estimated rates on fish ≥ 102 centimeters TL ranged to 11.5% in the 1980s (Kohlhorst and others 1991) while catch-per-unit-effort (DuBois and others 2011) and estimated abundance collapsed during that period (DuBois and others 2011, Schaffter and Kohlhorst 1999). If the amount of bias we have seen in 1998-2012 estimated rates is similar to the amount of bias in estimated rates from the 1960s through the mid-1990s, then — given annual total mortality rates (DuBois and others 2011, Kohlhorst 1979, Kohlhorst 1980, Kohlhorst et al. 1991, Miller 1972, Schaffter and Kohlhorst 1999) — harvest was the largest part of mortality during that period.

In response to the collapse in White Sturgeon catch-per-unit-effort and estimated abundance during the 1980s, the California Fish and Game Commission (Commission) in 1990 increased the minimum size limit and established a first-ever maximum size limit but made no change to the bag limit of 1 fish per day. Though no comprehensive information on fishing effort for White Sturgeon exists, fishing effort and harvest from Commercial Passenger Fishing Vessels before and after implementation of the maximum size limit were similar — which suggests that implementation of the maximum size limit focused intense fishing effort on a smaller fraction of the White Sturgeon population.

The Commission in 2007 implemented a suite of fishing regulations — including a 3-fish annual bag limit, a reduction in the maximum size limit, and the Report Card — expected to improve fishing for and the resiliency of White Sturgeon over time as well as to provide useful information on the population and patterns in sturgeon fishing. Report Cards have unexpectedly been the most-issued species-specific fishing license each year. Because there have been far fewer legal-sized White Sturgeon than have been authorized for harvest through the issuance of Report Cards, the risk of excessive harvest is substantial.

NOTE TO MANAGERS: Timely consideration should be given to the pros and cons of implementing an annual quota and/or further reduction in the annual bag limit, because White Sturgeon abundance is relatively low, poor recruitment has been prevalent since 1998 (DuBois and others submitted), annual harvest rate is high and has been trending upward, both fishing effort and interest are high, and California's only explicit White Sturgeon management objective has not been achieved approximately 2 decades after being established (Gingras and DuBois submitted).

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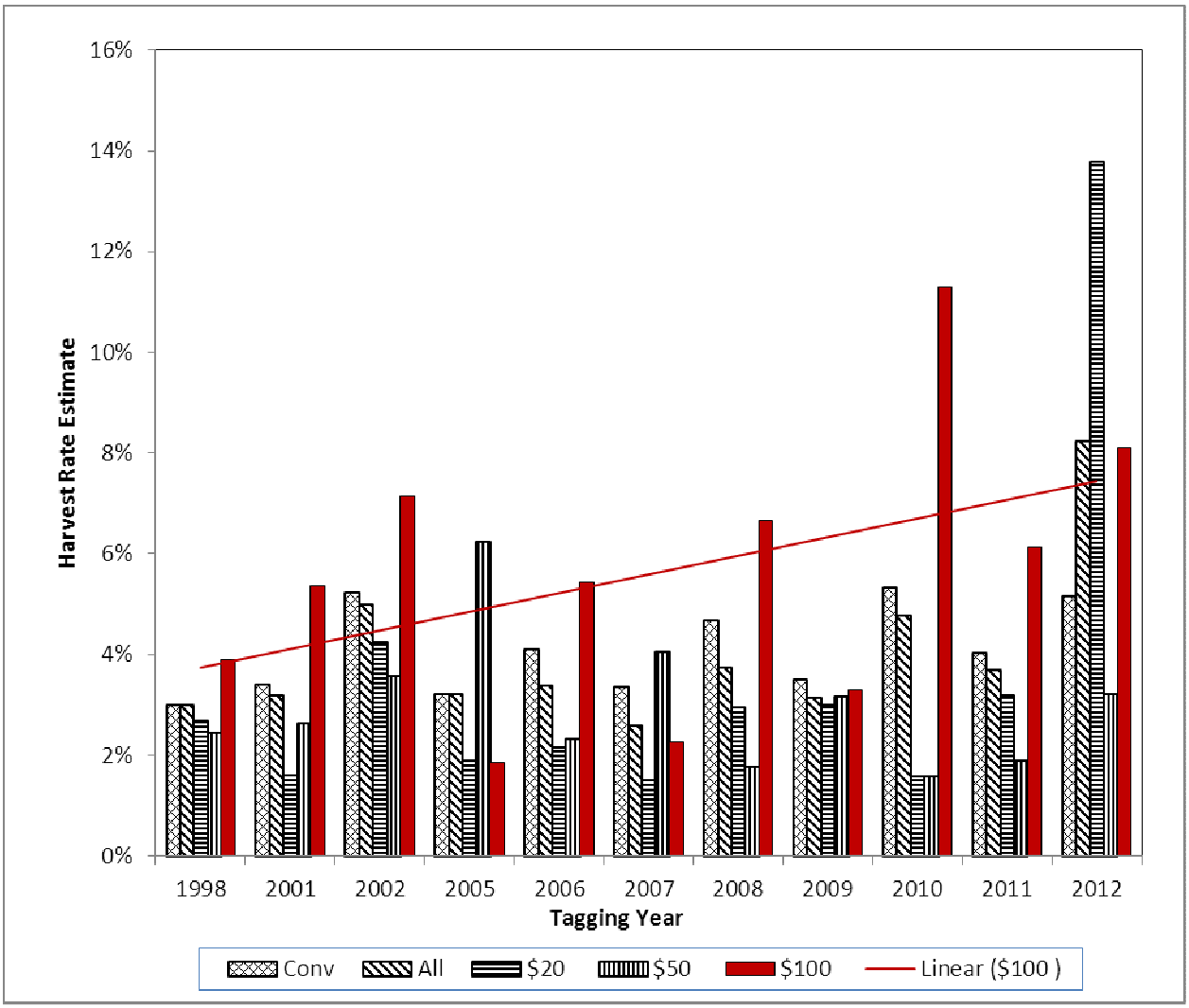

Figure 1. Annual harvest rates for San Francisco Estuary White Sturgeon from the following permutations of data: (a) The study's long-time 'conventional' algorithm that considers neither the reported fate of the fish or reward value (Conv), (b) fish reported as kept but without regard to reward value (All), and (c) fish reported as kept by each of 3 reward values ($20, $50, $100). Estimates for 2012 are preliminary.